The Annotation Game: Towards Collaborative Science with Humans, Robots, and AI
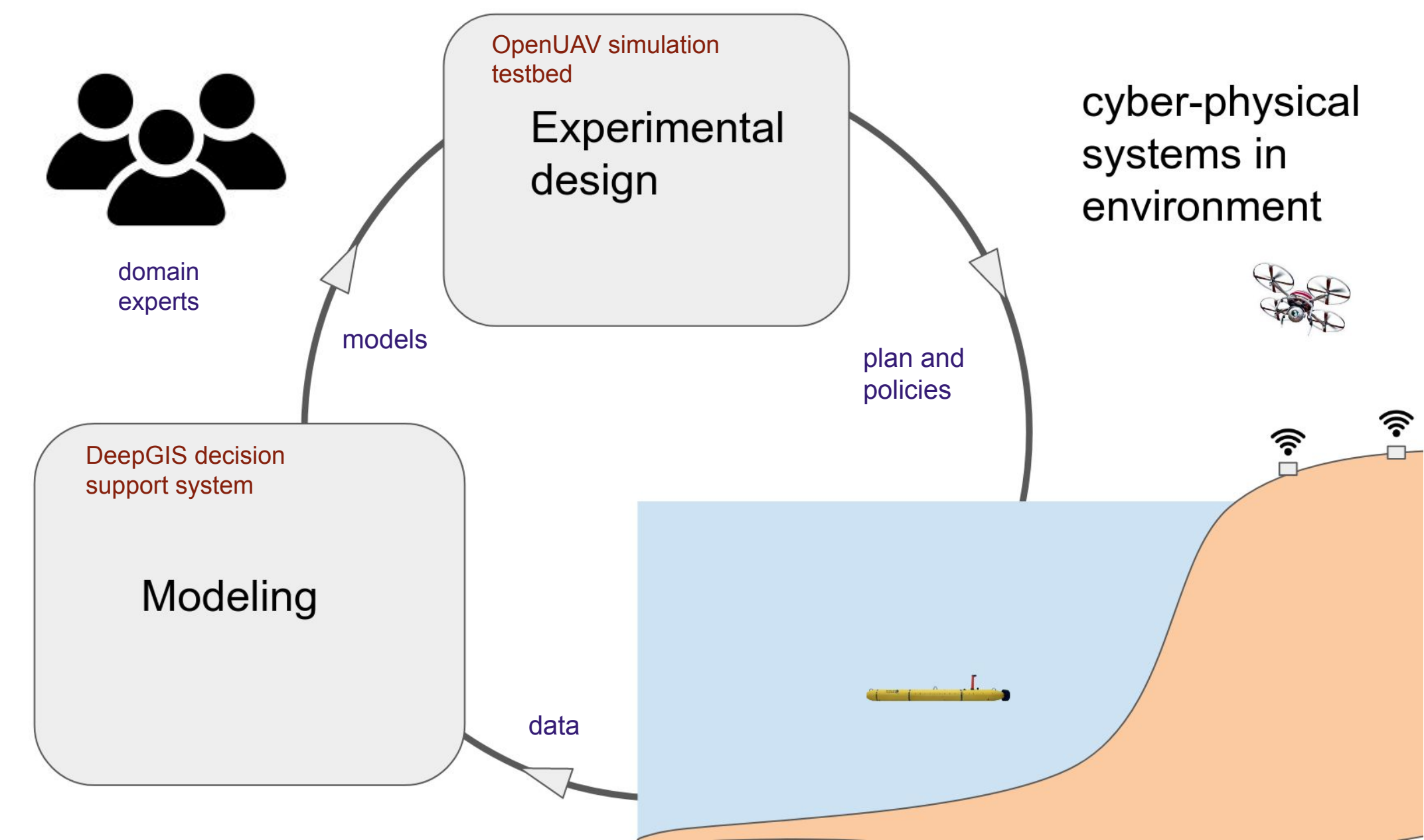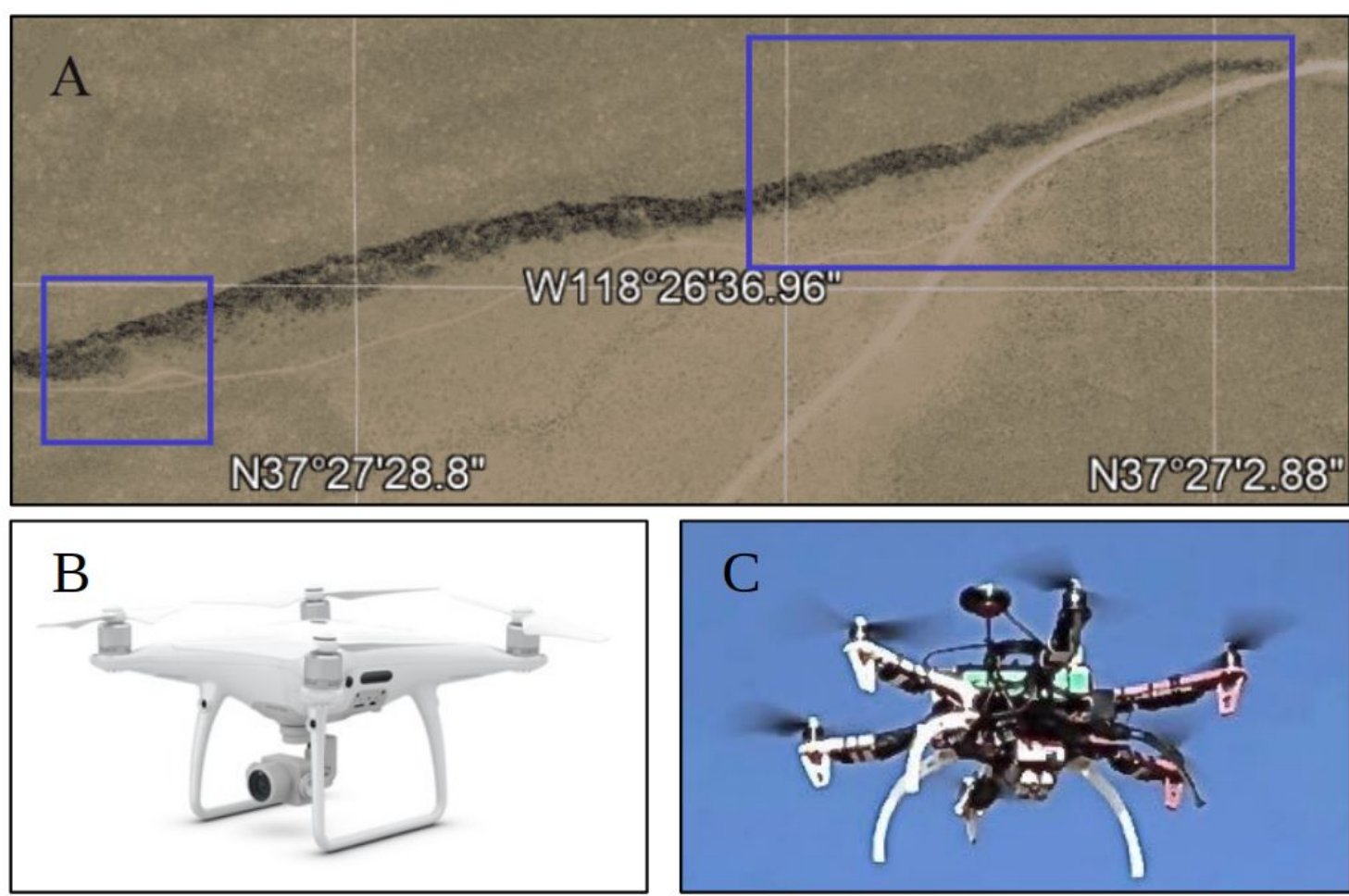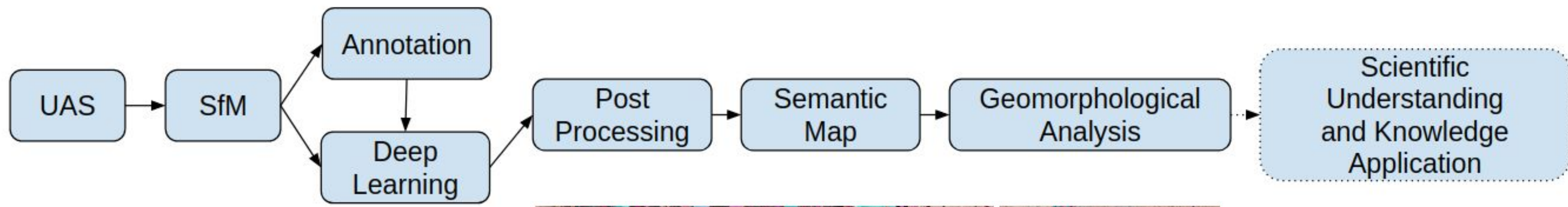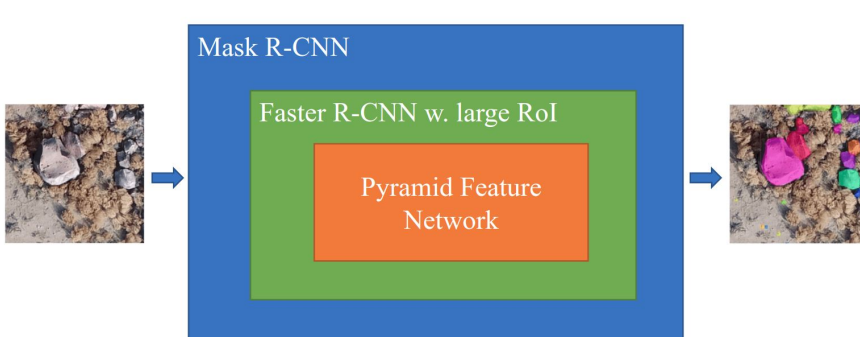
Zhiang Chen, Tyler R. Scott, Ethan Duncan, Harish Anand, A.L.G. Prasad, Sarah Bearman, Devin Keating, Chelsea Scott, Brent Hayashi, Mark Wronkiewicz, Jnaneshwar Das, Ramon Arrowsmith
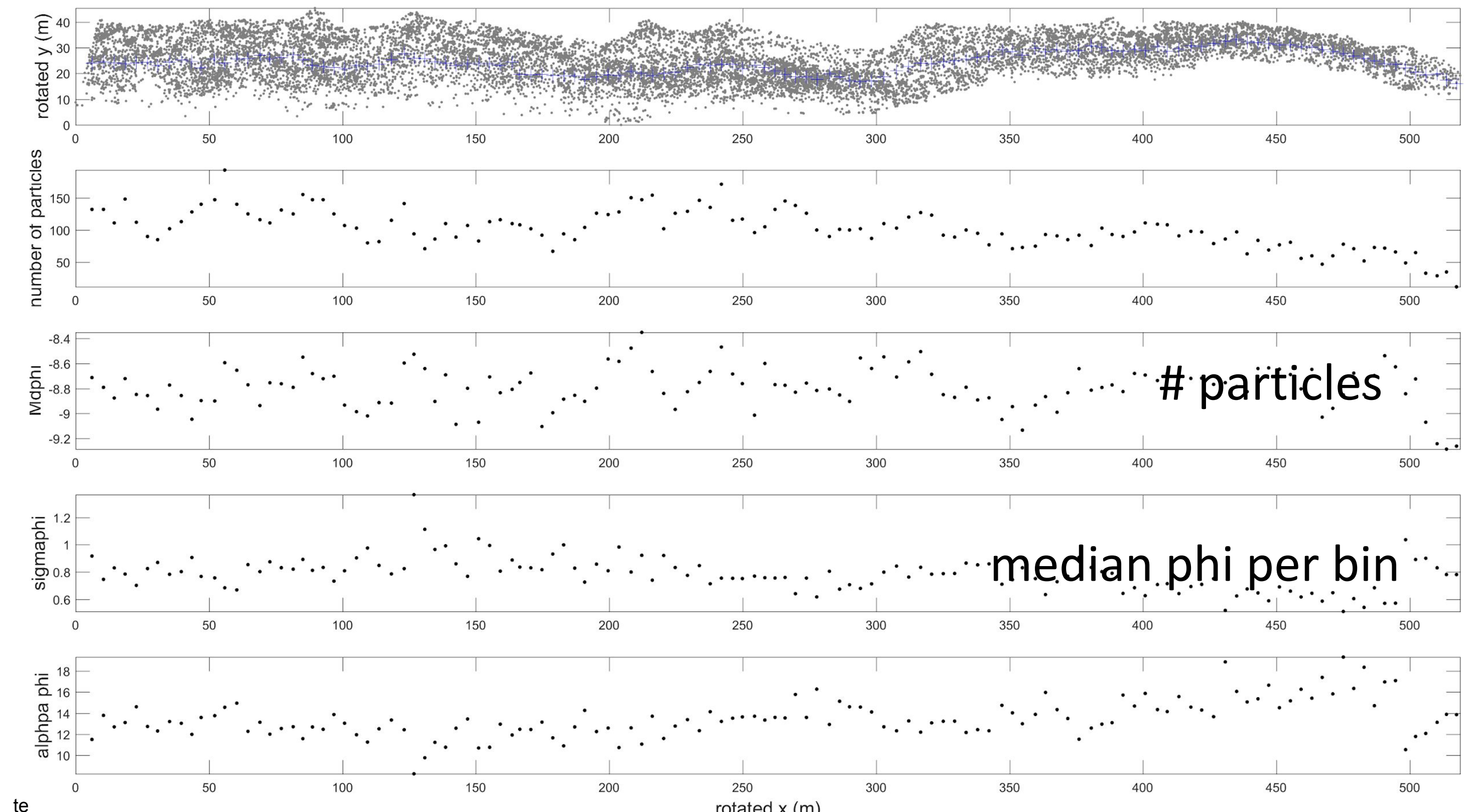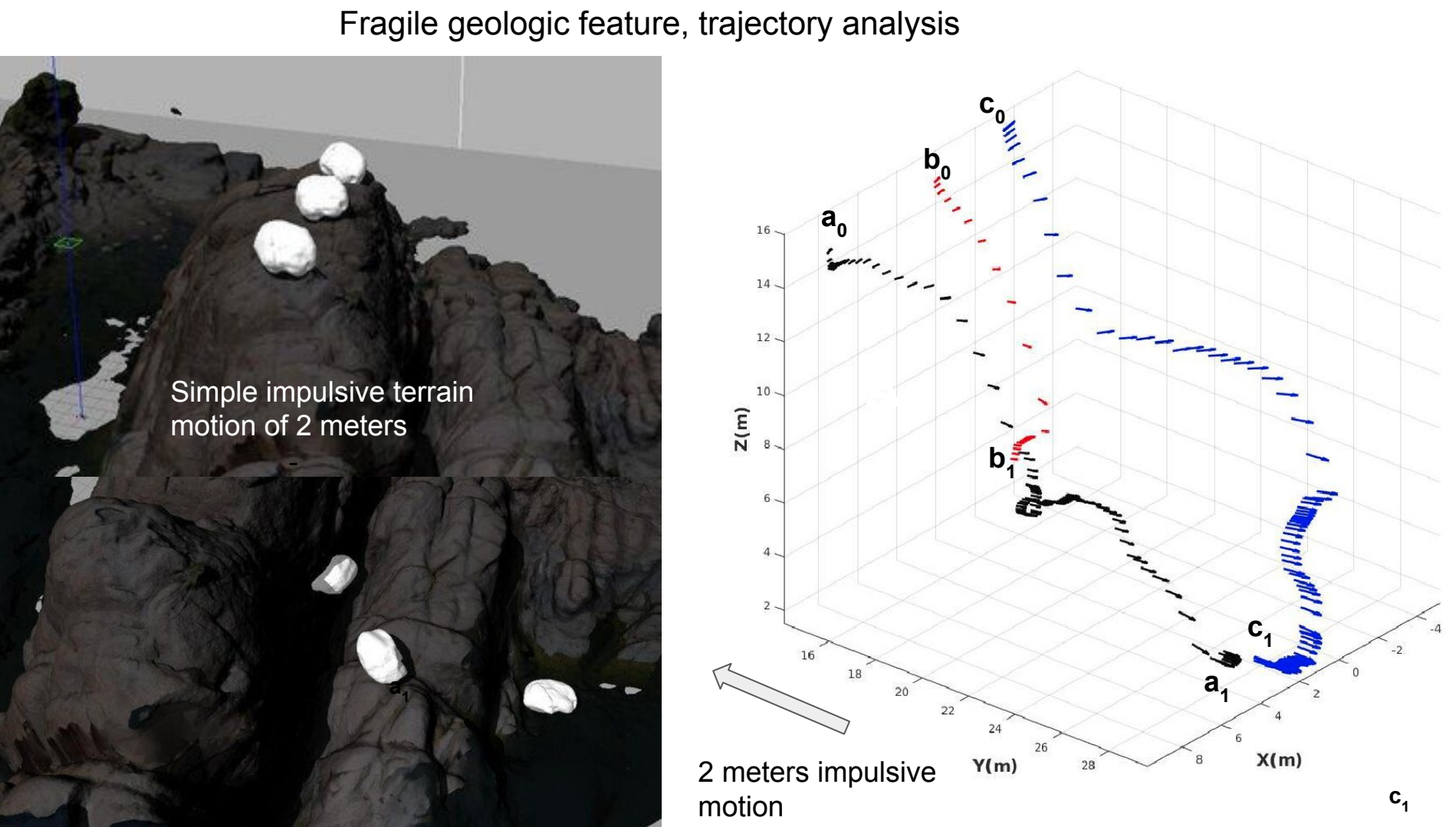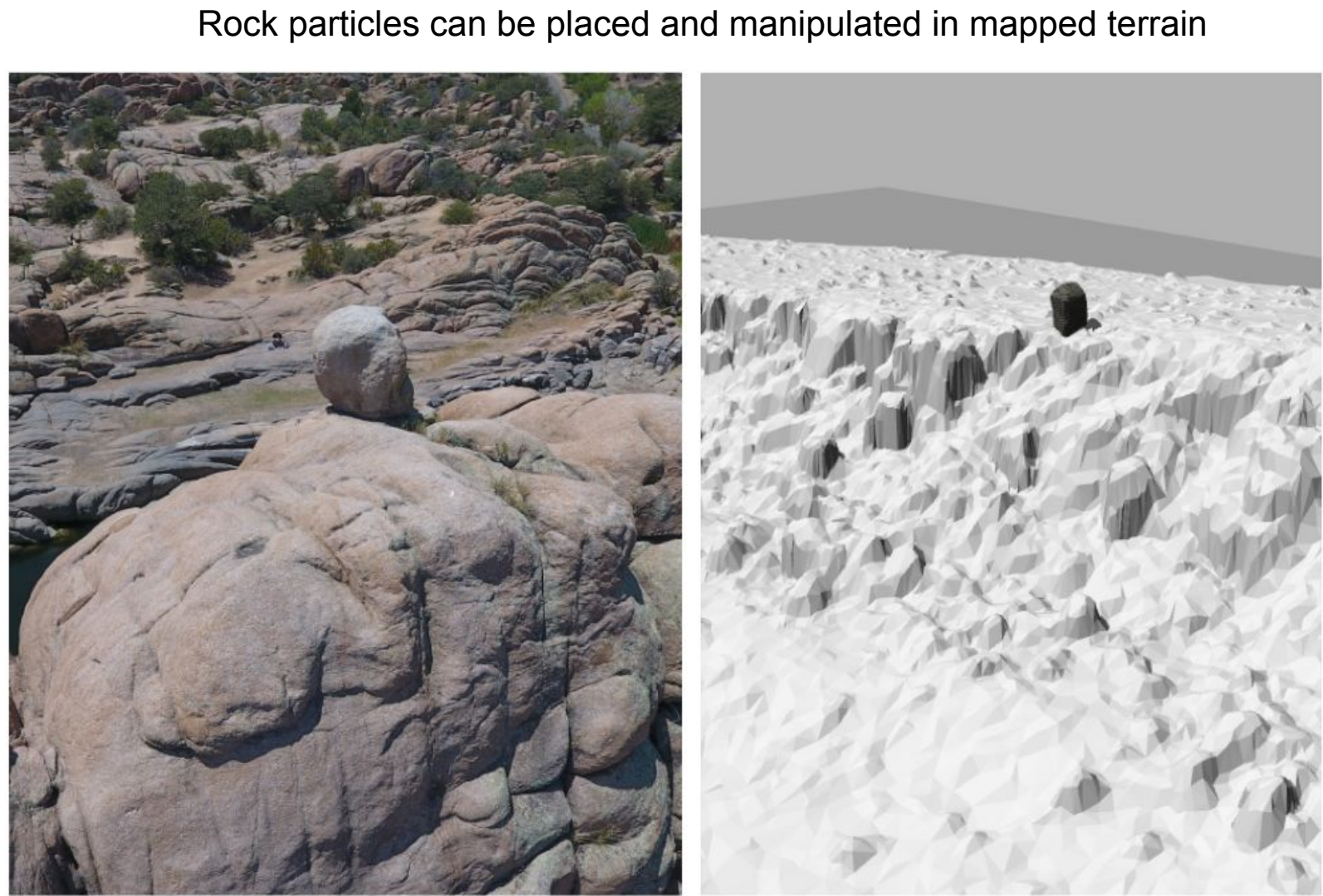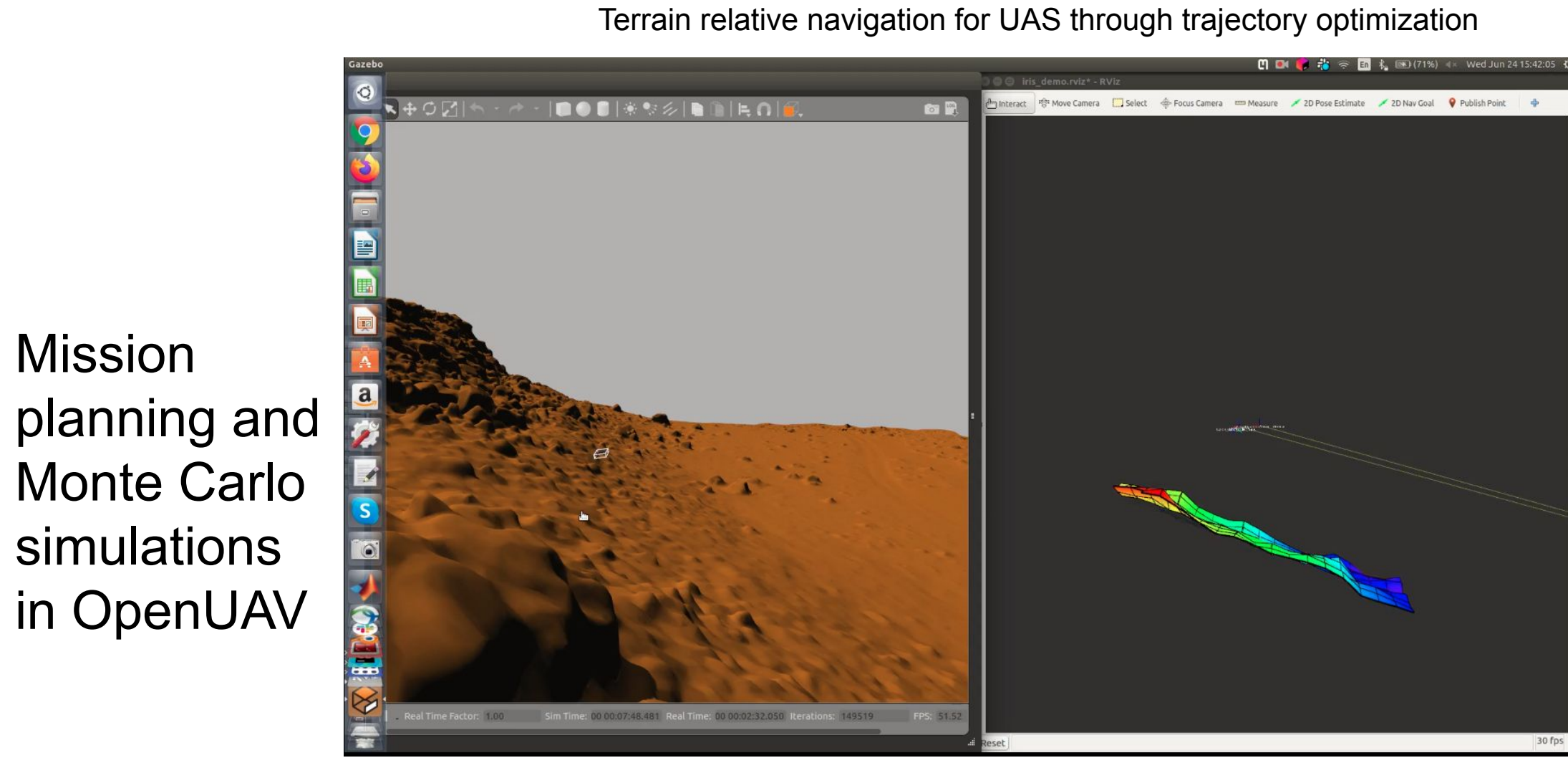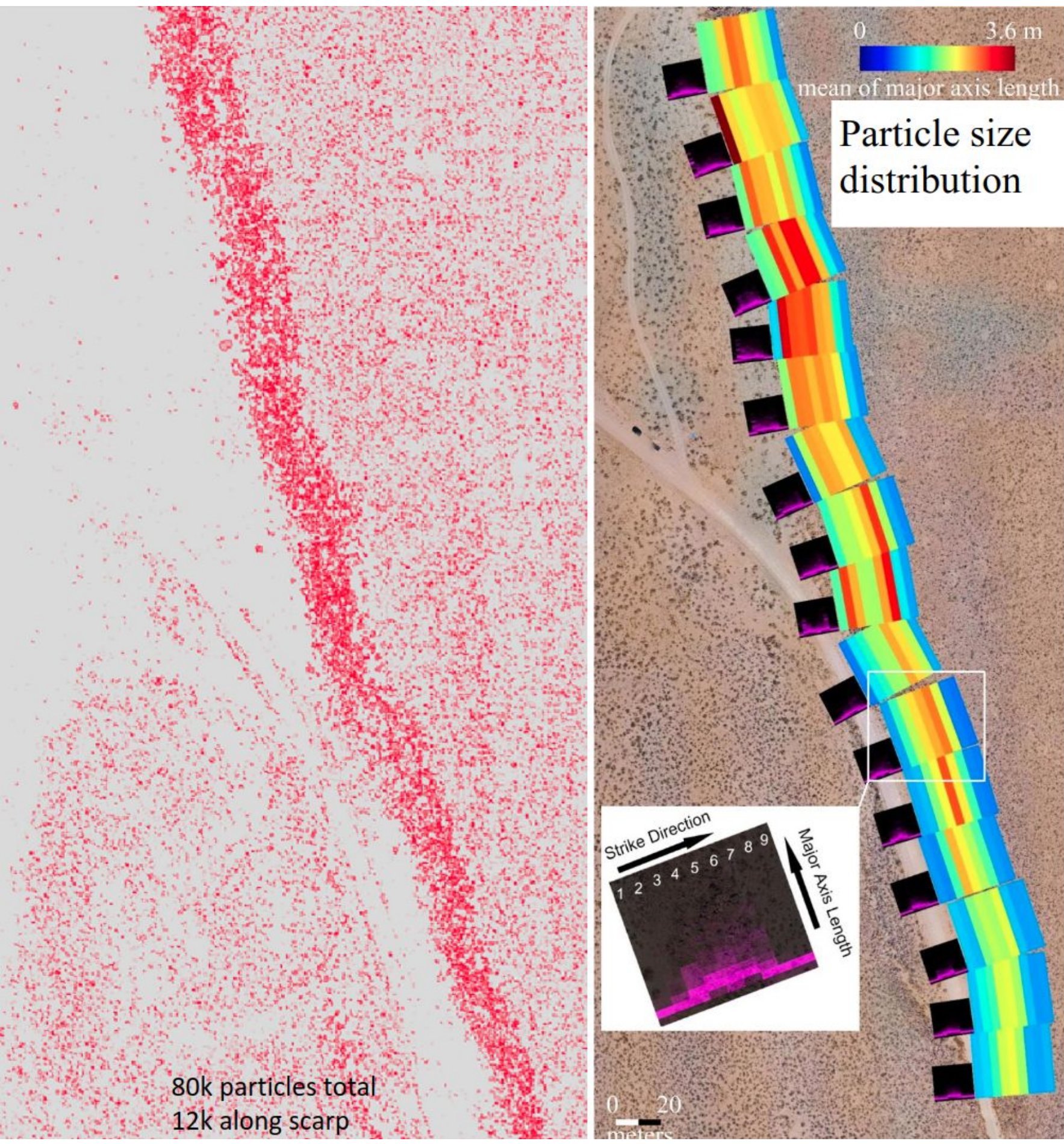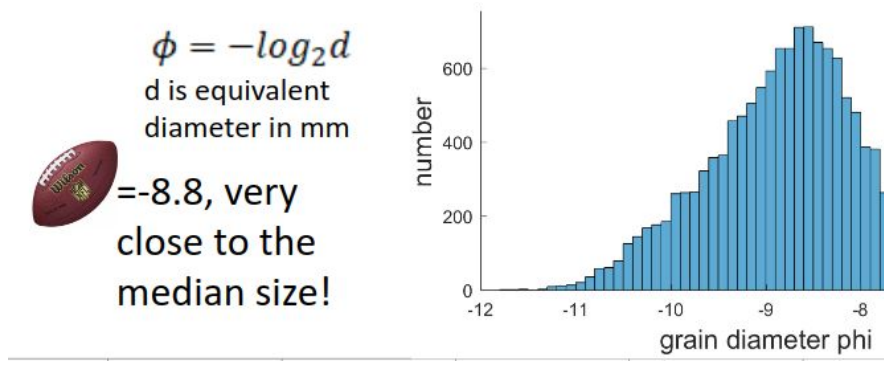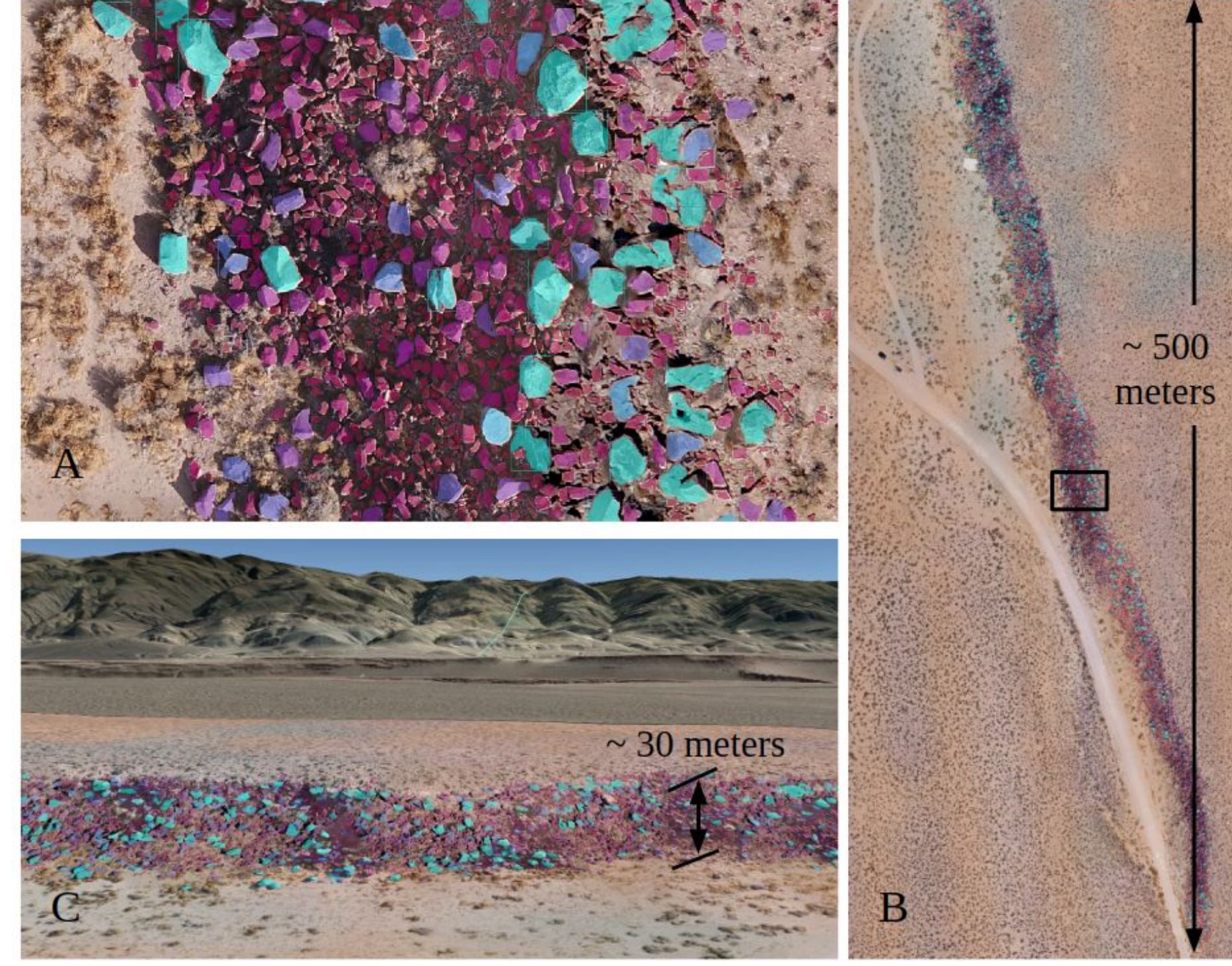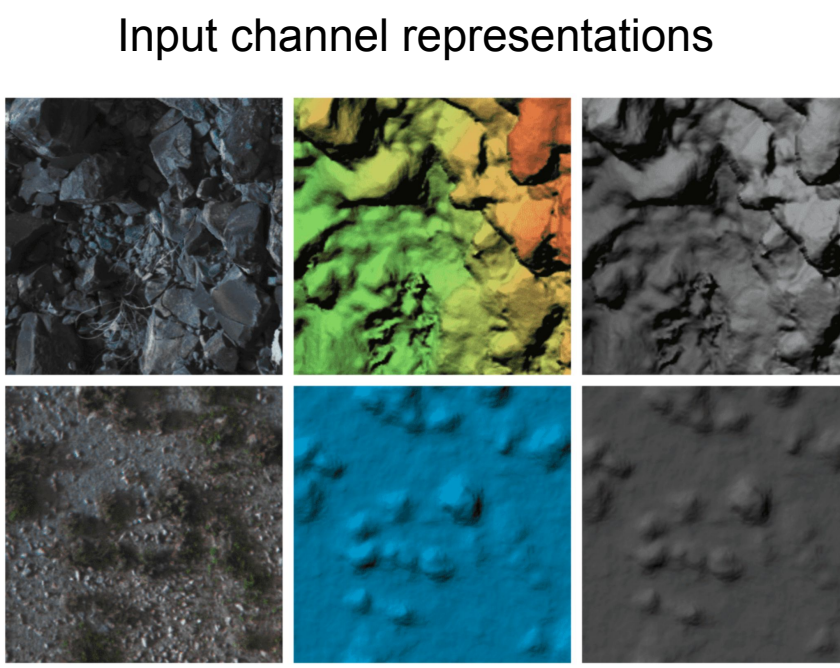

Data-driven rock geomorphology with UAS

Particle size distribution

80k particles total
12k along scarp

Input channel representations

RGB Orthomosaic tiles

Colormaps of digital elevation model (DEM)

Relative elevation

Deep neural network architecture

Mask R-CNN

Faster R-CNN w: large RoI

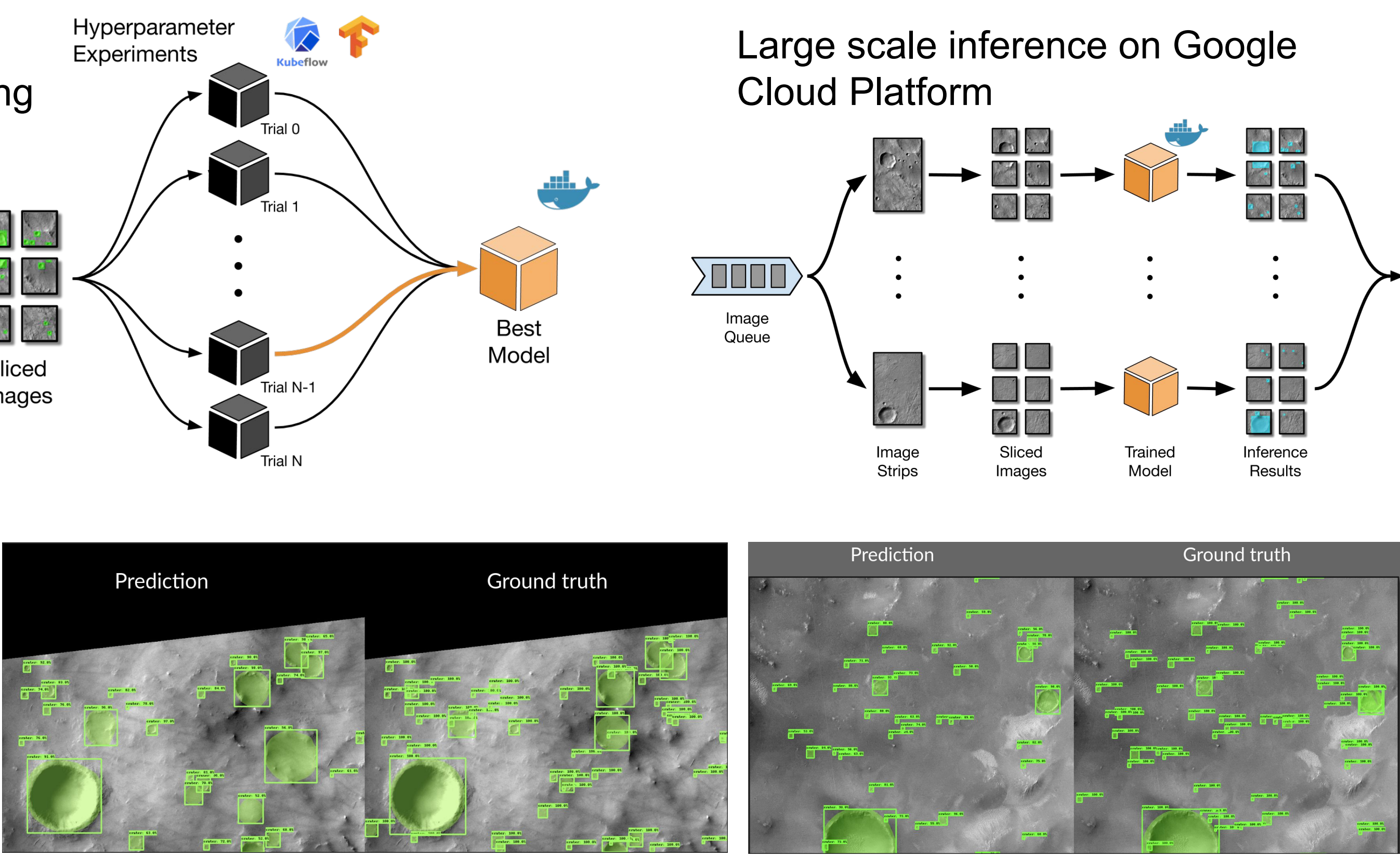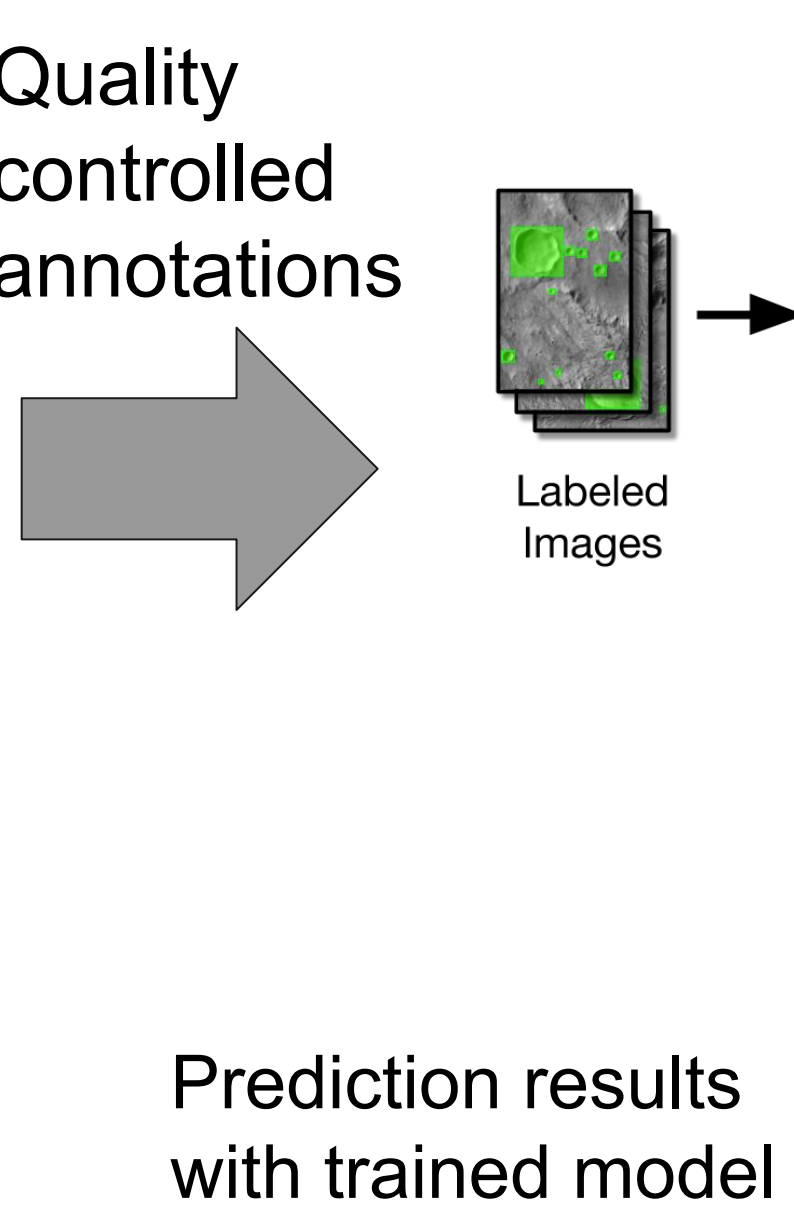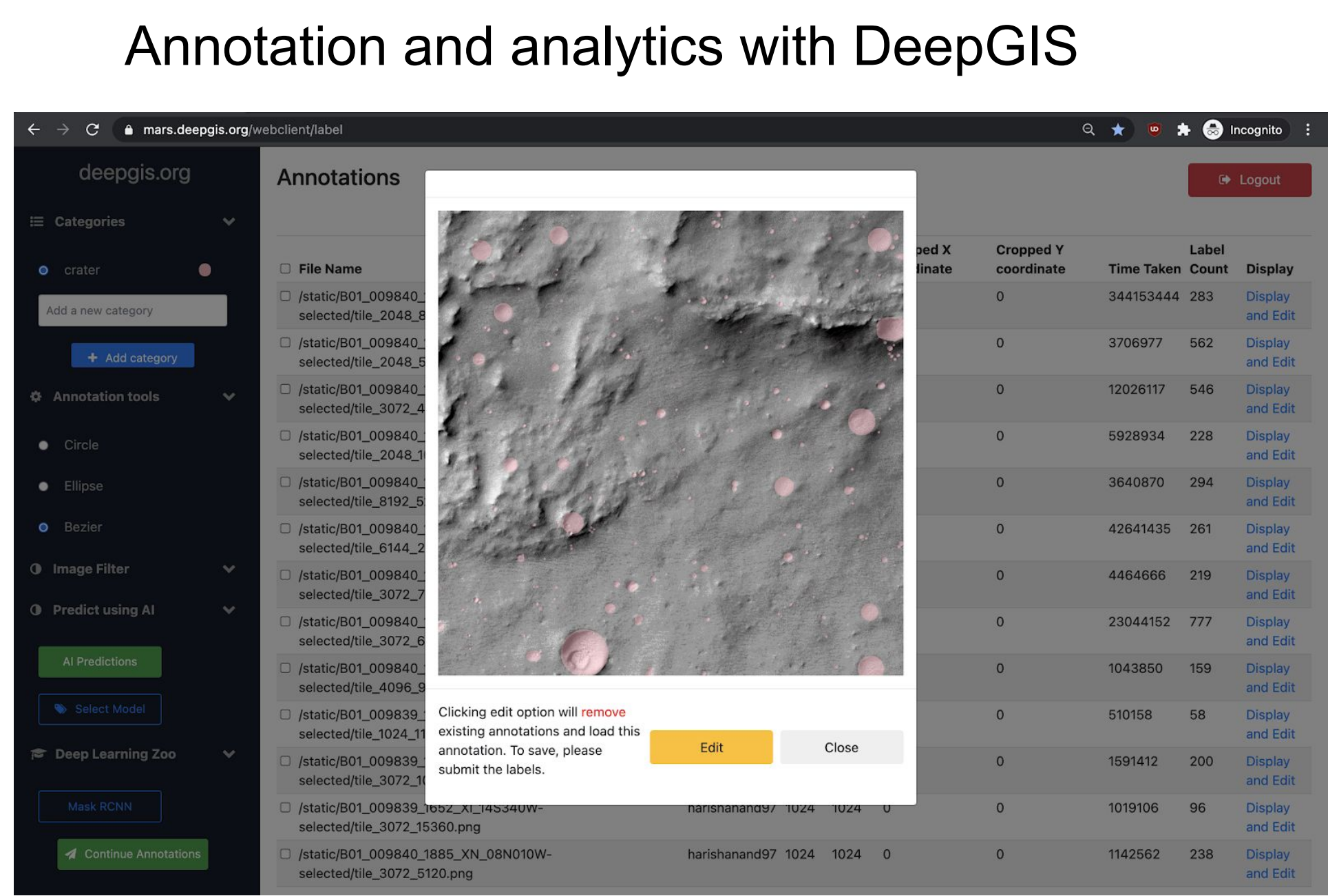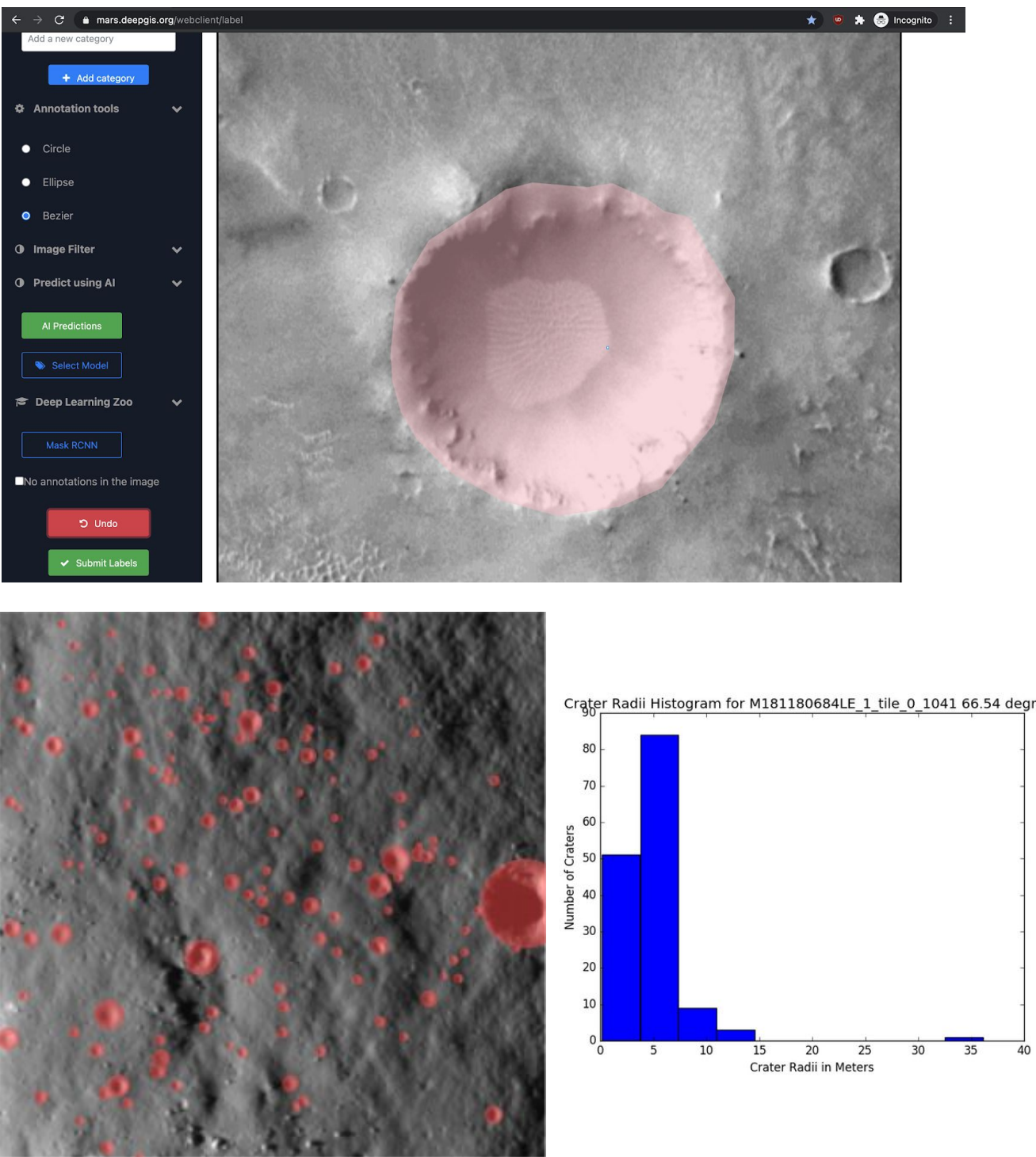Pyramid Feature Network

- Transfer learning > no transfer learning
- RGB + DEM3/DEM1 > RGB
- DEM1 alone is not enough due to bushes
- RGB + RE + NIR > RGB
- RGB + RG + NIR + DEM3/DEM1 have the best performance

- Mask R-CNN: Instance segmentation (individual rocks)
- Faster R-CNN with large number of Regions of Interest: up to 200 rocks in an input image
- Pyramid Feature Network: rock size varies largely in an input image (major-axis length: 0.2 ~ 3.6 meters)

~ 500 meters

~ 30 meters

$\phi = -log_2 d$
d is equivalent diameter in mm
=-8.8, very close to the median size!

Finer side sensitivity limitation

grain diameter phi

smaller

particles

median phi per bin

rotated y (m)

number of particles

Mdphi

sigmaphi

alpha phi

rotated x (m)

Terrain relative navigation for UAS through trajectory optimization

Rock particles can be placed and manipulated in mapped terrain

Fragile geologic feature, trajectory analysis

Mission planning and Monte Carlo simulations in OpenUAV

Simple impulsive terrain motion of 2 meters

2 meters impulsive motion

Planetary scale crater mapping

Annotation and analytics with DeepGIS

Crater Radii Histogram for M181190684E_1_tile_0_1041 66.54 degrees

Quality controlled annotations

Meta-learning

Hyperparameter Experiments

Trial 0

Trial 1

Trial N-1

Trial N

Best Model

Large scale inference on Google Cloud Platform

Image Queue

Image Strips

Sliced Images

Trained Model

Inference Results

Postgres Database

Prediction results with trained model

Prediction

Ground truth

Prediction

Ground truth

Summary

- Build upon robotic sampling, cloud, and machine learning.

- Leverage Bayesian optimization for metalearning, to guide annotation, model retraining, and large scale inference.

- AI assisted annotation and model retraining, lifelong learning with experts in the loop.

References:
1. Zhiang Chen, Tyler R. Scott, Sarah Bearman, Harish Anand, Chelsea Scott, J Ramón Arrowsmith, Jnaneshwar Das, "Geomorphological Analysis Using Unpiloted Aircraft Systems, Structure from Motion, and Deep Learning", in at IEEE/RSJ International Conference on Intelligent Robots and Systems (2020)
2. Harish Anand, Jnaneshwar Das, Zhiang Chen, "The OpenUAV Swarm Simulation Testbed: a Collaborative Design Studio for Field Robotics", submitted to IEEE International Conference on Robotics and Automation, 2021.

development SEED

Arizona State University

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SC/EC AN NSF+USGS CENTER Southern California Earthquake Center

NASA